

I CLAIM:

1 1. A process for producing liquified natural gas
2 comprising:

3 (A) operating a gas cooling loop by (1) contacting
4 a natural gas stream with a return stream of the gas
5 cooling loop to form a combined stream, wherein the
6 natural gas stream comprises methane and heavier
7 hydrocarbons, and the return stream comprises methane,

8 (2) passing the combined stream through a first zone of
9 a heat transfer zone and then to a gas cooling loop first
10 gas/liquid separation zone forming a first separation
11 zone gas stream comprising methane and a gas cooling loop
12 first separation zone liquid stream comprising heavier
13 hydrocarbons, (3) passing the first separation zone gas
14 stream through an expansion zone, then through a second
15 zone of the transfer zone, then through the first zone of
16 the heat transfer zone, and then through a compression
17 zone to form the return stream of the gas cooling loop;

18 (B) taking the gas cooling loop first separation
19 zone liquid stream as a distillation zone feed stream,
20 and distilling this distillation zone feed stream into a

21 distilled gas stream comprising methane and a bottom
22 stream comprising heavy hydrocarbons;

23 (C) operating an LNG cooling loop by (1) passing a
24 return stream of the LNG cooling loop to a compression
25 zone to form a compressed stream, (2) passing the
26 compressed stream thru the first zone of the heat
27 transfer zone and then through an expansion zone to form
28 a first expanded stream, (3) combining the first expanded
29 stream with the distilled gas stream from Step (B) to
30 form a combined LNG stream, (4) splitting the combined
31 LNG stream into a first return LNG stream and a first
32 remaining LNG stream, (5) expanding and passing the first
33 return LNG stream thru the first zone of the heat
34 transfer zone and then back to the compression zone, (6)
35 passing the first remaining LNG stream through the second
36 zone of the heat transfer zone and then splitting it into
37 a second return LNG stream and a second remaining LNG
38 stream, (7) expanding and passing the second return LNG
39 stream through the second zone of the heat transfer zone,
40 through the first zone of the heat transfer zone, and
41 then back to the compression zone, (8) passing the second

42 remaining LNG stream through a third zone of the heat
43 transfer zone and then splitting it into a third return
44 LNG stream and a third remaining LNG stream, (9) then
45 expanding and passing the third return LNG stream through
46 the third zone, the second zone and then the first zone
47 of the transfer zone to form the return stream of the LNG
48 cooling loop, and (10) passing the third remaining LNG
49 stream to LNG storage and recovering any LNG vapors as an
50 LNG boiloff stream and combining the boiloff stream with
51 the return stream of the LNG cooling loop, and recovering
52 LNG product from LNG storage as an LNG product stream.

1 2. The process of claim 1, further comprising:
2 in step (A), prior to contacting the natural gas
3 stream with a return stream of the gas cooling loop,
4 first removing any liquids from the natural gas stream,
5 which liquids are then combined with the distillation
6 zone feed stream of step (B)

1 3. The process of claim 1, further comprising:
2 removing a portion of the first separation zone gas

3 stream of step (A) as a side stream;

4 expanding the side stream and separating it into a
5 gas side stream and a liquid side stream;

6 combining the liquid side stream with the
7 distillation zone feed stream of step (B); and

8 passing the gas side stream through the second
9 portion of the heat transfer zone and combining it with
10 the first expanded stream and the distilled gas stream
11 from Step (B) to form the combined LNG stream.

1 4. A process for producing liquified natural gas
2 comprising:

3 (A) operating a gas cooling loop by (1) contacting
4 a natural gas stream with a return stream of the gas
5 cooling loop to form a combined stream, wherein the
6 natural gas stream comprises methane and heavier
7 hydrocarbons, and the return stream comprises methane,
8 (2) passing the combined stream through a heat transfer
9 zone and then to a gas cooling loop first gas/liquid
10 separation zone forming a first separation zone gas
11 stream comprising methane and a gas cooling loop first

12 separation zone liquid stream comprising heavier
13 hydrocarbons, (3) passing the first separation zone gas
14 stream through an expansion zone, then through the
15 transfer zone, and then through a compression zone to
16 form the return stream of the gas cooling loop;

17 (B) taking the gas cooling loop first separation
18 zone liquid stream as a distillation zone feed stream,
19 and distilling this distillation zone feed stream into a
20 distilled gas stream comprising methane and a bottom
21 stream comprising heavy hydrocarbons;

22 (C) operating an LNG cooling loop by (1) passing a
23 return stream of the LNG cooling loop to a compression
24 zone to form a compressed stream, (2) passing the
25 compressed stream thru the heat transfer zone and then
26 through an expansion zone to form a first expanded
27 stream, (3) splitting the first expanded stream into a
28 first return LNG stream and a first remaining LNG stream,
29 (4) expanding and passing the first return LNG stream
30 through the heat transfer zone and then back to the
31 compression zone, (5) passing the first remaining LNG
32 stream through the heat transfer zone and then splitting

33 it into a second return LNG stream and a second remaining
34 LNG stream, (6) expanding and passing the second return
35 LNG stream through the heat transfer zone, and then back
36 to the compression zone, (7) passing the second remaining
37 LNG stream through the heat transfer zone and then
38 splitting it into a third return LNG stream and a third
39 remaining LNG stream, (8) then expanding and passing the
40 third return LNG stream through the transfer zone to form
41 the return stream of the LNG cooling loop, (9) passing
42 the third remaining LNG stream to LNG storage and
43 recovering any LNG vapors as an LNG boiloff stream and
44 combining the boiloff stream with the return stream of
45 the LNG cooling loop, and recovering LNG product from LNG
46 storage as an LNG product stream, and (10) introducing
47 the distilled gas stream from Step (B) into the LNG
48 cooling loop

1 5. An apparatus for processing natural gas, the
2 apparatus comprising:

3 a gas cooling loop unit comprising, a natural gas
4 inlet line for receiving the natural gas, a heat exchange

5 zone, a gas/liquid separation zone having a gas exit line
6 and a liquid exit line, an gas cooling loop expansion
7 zone, and a gas cooling loop compression zone, and gas
8 cooling loop piping defining a gas cooling loop flow path
9 suitable to allow the received natural gas from the inlet
10 line to be combined with a gas cooling loop recycled gas
11 from the compression zone and flow, through a first path
12 through the heat exchange zone, to the gas/liquid
13 separator wherein any condensed liquid exits through the
14 liquid exit line, and any remaining gas exits through the
15 gas exit line, with the remaining gas then passing
16 through the expansion zone, through a second path through
17 the heat exchange zone, through the compression zone to
18 be recycled back as the gas cooling loop recycled gas;

19 a distillation unit having an inlet, a gas outlet,
20 and a liquid outlet, wherein the inlet is connected to
21 the gas cooling loop liquid exit line;

22 an LNG cooling loop unit, an LNG compression zone,
23 the heat exchanger zone, an LNG expander, an LNG recovery

24 unit, and LNG piping defining an LNG cooling loop path
25 suitable to allow a compressed LNG boiloff gas and a
26 third LNG recycle gas to be combined into a combined gas
27 which flows through the LNG compression zone, through a
28 third path through the heat exchange zone, through the
29 expander, and through a first LNG splitter and split into
30 a first LNG recycle gas and a first LNG remaining gas,
31 with the first remaining gas flowing through a fourth
32 path through the heat exchange zone, and through a second
33 LNG splitter and split into a second LNG recycle gas and
34 a second LNG remaining gas, with the second remaining gas
35 flowing through a fifth path through the heat exchange
36 zone, and through a third LNG splitter and split into a
37 third LNG recycle gas and a third LNG remaining gas, with
38 the third LNG remaining gas passing through the
39 distillation unit, and distilled into the compressed LNG
40 boiloff gas and an LNG product, with the first LNG
41 recycle gas passing through a sixth path through the heat
42 exchange zone and recycled through the compression zone,
43 with the second LNG recycle gas passing through a seventh
44 path through the heat exchange zone and recycled through

the compression zone, and with the third LNG recycle gas passing through a eighth path through the heat exchange zone and recycled to be combined with the LNG boiloff gas,

wherein the distillation gas outlet is connected to the LNG cooling loop.

6. The apparatus of claim 6, wherein the distillation gas outlet is connected to the LNG cooling loop immediately prior to the fourth path through the heat exchanger zone.

7. An apparatus for processing natural gas, the apparatus comprising:

a gas cooling loop unit comprising, a natural gas inlet line for receiving the natural gas, a heat exchange unit having first, second, and third zones, a gas/liquid separation zone having a gas exit line and a liquid exit line, an gas cooling loop expansion zone, and a gas cooling loop compression zone, and gas cooling loop piping defining a gas cooling loop flow path suitable to

allow the received natural gas from the inlet line to be combined with a gas cooling loop recycled gas from the compression zone and flow, through a first path through the first zone of the heat exchange unit, to the gas/liquid separator wherein any condensed liquid exits through the liquid exit line, and any remaining gas exits through the gas exit line, with the remaining gas then passing through the expansion zone, through a second path through the second zone and then first zone of the heat exchange unit, through the compression zone to be recycled back as the gas cooling loop recycled gas;

a distillation unit having an inlet, a gas outlet, and a liquid outlet, wherein the inlet is connected to the gas cooling loop liquid exit line;

an LNG cooling loop unit comprising, an LNG compression zone, the heat exchanger unit, an LNG expander, an LNG recovery unit, and LNG piping defining an LNG cooling loop path suitable to allow a compressed LNG boiloff gas and a third LNG recycle gas to be

combined into a combined gas which flows through the LNG compression zone, through a third path through the first zone of the heat exchange unit, through the expander, and through a first LNG splitter and split into a first LNG recycle gas and a first LNG remaining gas, with the first remaining gas flowing through a fourth path through the second zone of the heat exchange unit, and through a second LNG splitter and split into a second LNG recycle gas and a second LNG remaining gas, with the second remaining gas flowing through a fifth path through the third zone of the heat exchange unit, and through a third LNG splitter and split into a third LNG recycle gas and a third LNG remaining gas, with the third LNG remaining gas passing through the distillation unit, and distilled into the compressed LNG boiloff gas and an LNG product, with the first LNG recycle gas passing through a sixth path through the first zone of the heat exchange unit and recycled through the compression zone, with the second LNG recycle gas passing through a seventh path through second zone and then first zone of the heat exchange unit and recycled through the compression zone, and with the

50 third LNG recycle gas passing through a eighth path
51 through the third zone, then second zone, and then first
52 zone of the heat exchange unit and recycled to be
53 combined with the LNG boiloff gas,
54 wherein the distillation gas outlet is connected to
55 the LNG cooling loop unit.

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